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THESIS

INFORMATION TRANSFER IN 2-, 3-, AND 4-WORD VERBAL DISCRIMINATION LEARNING WITH TWO STIMULUS PRESENTATION RATES

by

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by

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ABSTRACT

Sixty Naval Postgraduate School students served in a verbal discrimination (VD) experiment with 2-, 3-, and 4-word items at presentation rates of $\frac{1}{2}$ or $\frac{1}{4}$ bits of information per second. Half the items had similar and half, dissimilar words. Based on information theory, lists of different lengths were prepared for 2-, 3-, and 4-word items. The lists were equated for overall load at 20 bits of information. Performance was consistent with the equal-load hypothesis and a differential of two was observed because of the rate factor. Analysis of percent correct responses revealed a significance for the item length main effect which was at variance with the null hypothesis of no difference borne out by the information analysis.

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I. INTRODUCTION

Verbal learning is a form of learning in which all persons engage, and which is an integral part of educational procedures. Verbal discrimination (VD) is a method of presenting verbal material for learning. A set of words (called an item) is presented to the subject, and he must select the one that has been arbitrarily selected as correct by the experimenter.[1] A VD list of items is selected and presented to the subject; one complete presentation of the list is called a trial and on successive trials the words within an item and the items themselves are presented in different orders. Some studies have used a blank interval between presentations of each item.

On the first trial of a VD task the subject is requested to make a guess for each item as to the correct word. In the contingent method, his response, if correct, is usually reinforced by the experimenter who records each response the subject makes. In subsequent trials, it is hoped that the subject will learn the correct words in the list through this reinforcement and that the experimenter will be able to analyze these responses in order to measure the amount of learning incurred.

Learning difficulty varies as the number of choices within each item (Underwood and Freund 1969). Zacks (1969) has shown that the total learning time tends to be invariant over various conditions of practice for a fixed task load. Gray (1971) has demonstrated that information analysis of VD tasks provides additional information over conventional methods of analyzing VD learning. For example, the information measure provides an

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[1] The usual method is by use of a random choice mechanism.

absolute measure of learning regardless of the number of alternatives, whereas a measure such as the percentage of correct responses will vary according to the number of alternatives. Information measures, when the responses are summed over individuals, also provide information regarding the patterning of choices over all the alternatives considered simultaneously. That is, when the initial probability of choice for each word in a VD list can be estimated, the transfer of information contained within the list may then be measured by the distribution of responses among choices over repeated trials. Thus, learning can be analyzed as the reduction in uncertainty of subjects' responses from the uncertainty initially present in the item.

If all the choices within an item are equally likely, then the information content of the item is simply defined as

$$I = \log_2 N$$

where N equals the number of words within the item. Hence, a 2-word item has 1 bit of information; a 3-word item, 1.585 bits; a 4-word item, 2 bits, etc.

In the general case, considering a list of m items, each containing n-words, the information content would be

$$I = - \sum_{k=1}^{m} \left[\sum_{i=1}^{n} (p_i \log_2 p_i) \right]$$

where k is the k-th item within the list and p_i is the probability of occurrence of the i-th word within the k-th item. P_i may also be expressed as the a priori probability of choice for each word within the VD item. Using these notions, this study examined the learning of 2-, 3-, and 4-word items using two information (stimulus) presentation rates. This is

in contrast to Gray's (1971) study in which he used two presentation times regardless of the information content of the stimulus. When the information load for each list is approximately the same and the information presentation rate is constant (regardless of the number of words in an item), there should be no difference in the information presentation rates; difference in performance should be proportional to the differences in presentation rates.

II. METHOD

A. WORD LISTS

Three word lists (Table I), one for each of the 2-, 3-, and 4-word treatments, constrained to a maximum uncertainty of 20 bits[2], were constructed. For the uncertainty level selected, lists of 20, 12, and 10 VD items were required for the 2-, 3-, and 4-word treatments, respectively. To insure the equal *a priori* probability of selection on the first trial and to reduce the rate of learning bias (Sidowski, 1966), three criteria were used in determining the words in each list. First, these words were selected from categories having at least a 0.9 correlation over test subjects in the category norms for verbal items compiled by Battig and Montague (1969). Secondly, similarity was established by selecting the words of an item from a single category. Half of the items in each list were composed in this manner; the remaining items contained dissimilar groupings. Finally, the frequence of occurrence of each word in written material was examined using the Thorndike and Lorge (1944) general count.

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[2]In order to maintain list compatability for similar and dissimilar words, the 3-word VD list contained 19.02 bits of uncertainty.

TABLE I

WORD LISTS FOR 2-, 3-, AND 4-WORD TREATMENTS

TWO-WORD TREATMENTS

murder	wine*	juice	doll*
apple	river*	book	lake*
iron	yard*	nail	swim*
tea	coffee	temple	rock*
table	chair	cotton	salt*
mother	father	bus	gun*
cat	dog	water	door*
eye	head	car	train
foot	mile	red	blue
corn	bean	hour	minute

THREE-WORD TREATMENTS

door	temple	water*
brother	mother	father
green	blue	red
lake	book	table*
cotton	hours	salt*
apple	knife	cat*
iron	yard	doctor*
eye	head	foot
minute	hour	second
hill	river	rock
boat	train	car
nail	oil	swim*

FOUR-WORD TREATMENTS

mother	sister	hour	father
door	private	temple	water*
eye	foot	nose	head
swim	nail	wine	oil*
yard	doctor	iron	book*
yellow	blue	green	red
lake	rock	river	hill
cotton	salt	house	table*
cat	murder	knife	apple*
year	minute	hour	second

*Denotes dissimilar word groups.. First word in each item was used as the correct response with the experiment.

In this respect, all words were required to be members of the AA or A frequency group.

B. CONDITIONS AND PROCEDURES

From each of the three word lists two treatments were constructed. One treatment from each list was randomly assigned to one of two presentation rate groups, yielding six treatments. Each treatment consisted of two copies of four random arrangements of the items within the respective list and a random arrangement of the words within each item; thus, eight presentations of each list were used to examine the trends in the results.

For each list, one word within each item was designated correct by random determination, and remained correct throughout the experiment.

Prior to each treatment, the subjects were read a set of instructions on the task and the procedures (Appendix A). The subjects were tested individually using a Lafayette high-speed memory drum. The discrimination item was presented for a fixed-time interval followed by an inter-item interval of the same duration as noted in Table II. The subject viewed

TABLE II.

TIME INTERVALS FOR ITEM PRESENTATION

ITEM TYPE	PRESENTATION RATE	
	$\frac{1}{2}$ BITS/SEC	$\frac{1}{4}$ BITS/SEC
2-WORD	1.0	2.0
3-WORD	1.6	3.2
4-WORD	2.0	4.0

the words in an item, chose what he considered the correct word and told his choice to the experimenter. This declaration was reinforced with the

verbal response "correct" from the experimenter when the right word was chosen; otherwise, there was no response from the experimenter. Each response from the subject was recorded and formed the basic data for the analysis. There were no intertrial breaks.

C. SUBJECTS

The 60 subjects were graduate level students at the Naval Postgraduate School. They were volunteers and randomly assigned to six study groups, of 10 subjects each, associated with each of the six treatments.

III. RESULTS

The results will first be analyzed according to the growth of correct responses; then an analysis in terms of information transfer findings will be made. The percent correct responses per trial by item length and presentation rate, by presentation rate, and by item length are shown in Tables III, IV and V and Figures 1, 2, 3, and 4 respectively.

TABLE III

PERCENT OF CORRECT RESPONSES PER TRIAL

BY PRESENTATION RATE AND ITEM LENGTH

TRIAL	½ BITS/SEC			¼ BITS/SEC		
	2-WORDS	3-WORDS	4-WORDS	2-WORDS	3-WORDS	4-WORDS
1	51.0	34.2	19.0	47.5	35.8	25.0
2	55.5	39.2	33.0	67.5	46.7	32.0
3	59.0	55.0	36.0	73.5	44.2	46.0
4	61.5	52.5	50.0	85.0	57.5	56.0
5	64.5	57.5	49.0	85.0	59.2	67.0
6	64.5	63.3	49.0	87.5	66.7	63.0
7	67.0	70.8	58.0	91.0	74.2	75.0
8	74.0	71.7	60.0	93.5	80.8	81.0

TABLE IV

PERCENT OF CORRECT RESPONSES PER TRIAL

BY PRESENTATION RATE

TRIAL	PRESENTATION RATE	
	$\frac{1}{2}$ BITS/SEC	$\frac{1}{4}$ BITS/SEC
1	38.6	38.8
2	45.5	53.1
3	52.4	58.6
4	56.2	70.2
5	58.8	73.3
6	60.5	75.7
7	66.0	82.4
8	70.0	86.9

TABLE V

PERCENT OF CORRECT RESPONSES PER TRIAL BY ITEM LENGTH

TRIAL	ITEM LENGTH		
	2-WORD	3-WORD	4-WORD
1	49.3	35.0	22.0
2	57.5	43.0	32.5
3	66.3	49.6	41.0
4	73.3	55.0	53.0
5	74.8	58.4	58.0
6	76.0	65.0	56.0
7	79.0	72.5	66.5
8	83.8	76.3	70.5

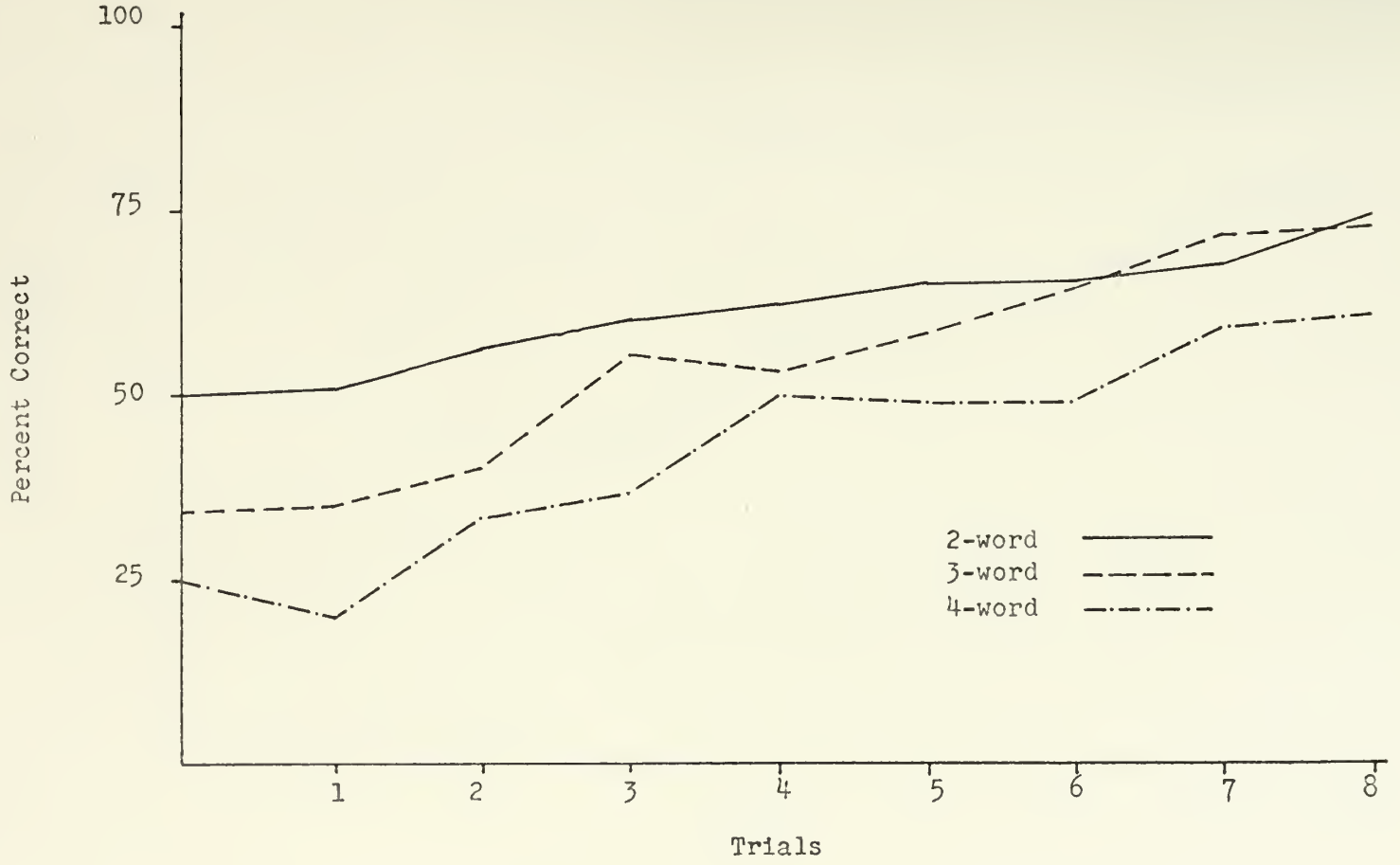

Figure 1. Percent Correct Responses at a Presentation Rate of $\frac{1}{2}$ Bits/Sec

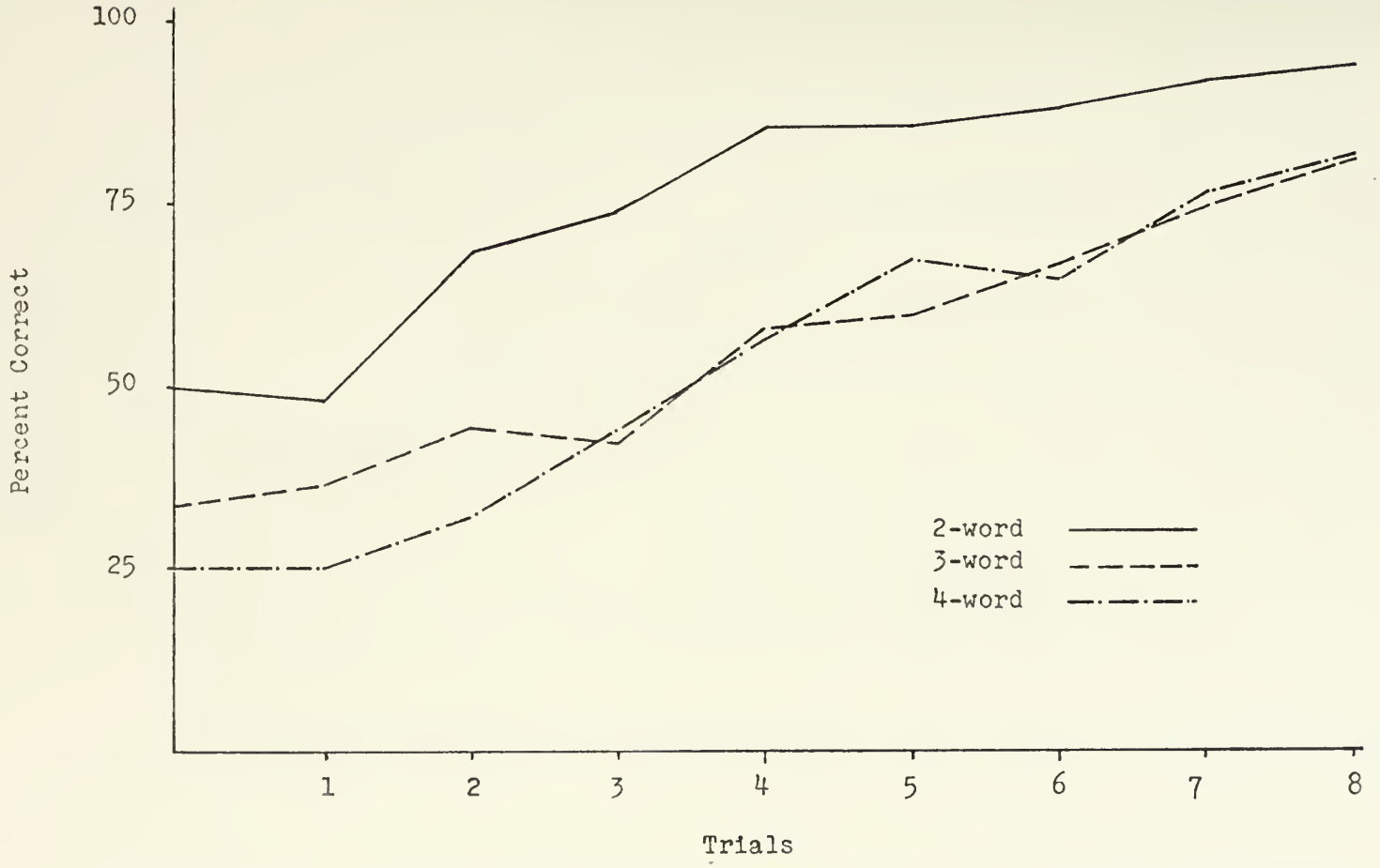

Figure 2. Percent Correct Responses at a Presentation Rate of $\frac{1}{4}$ Bits/Sec

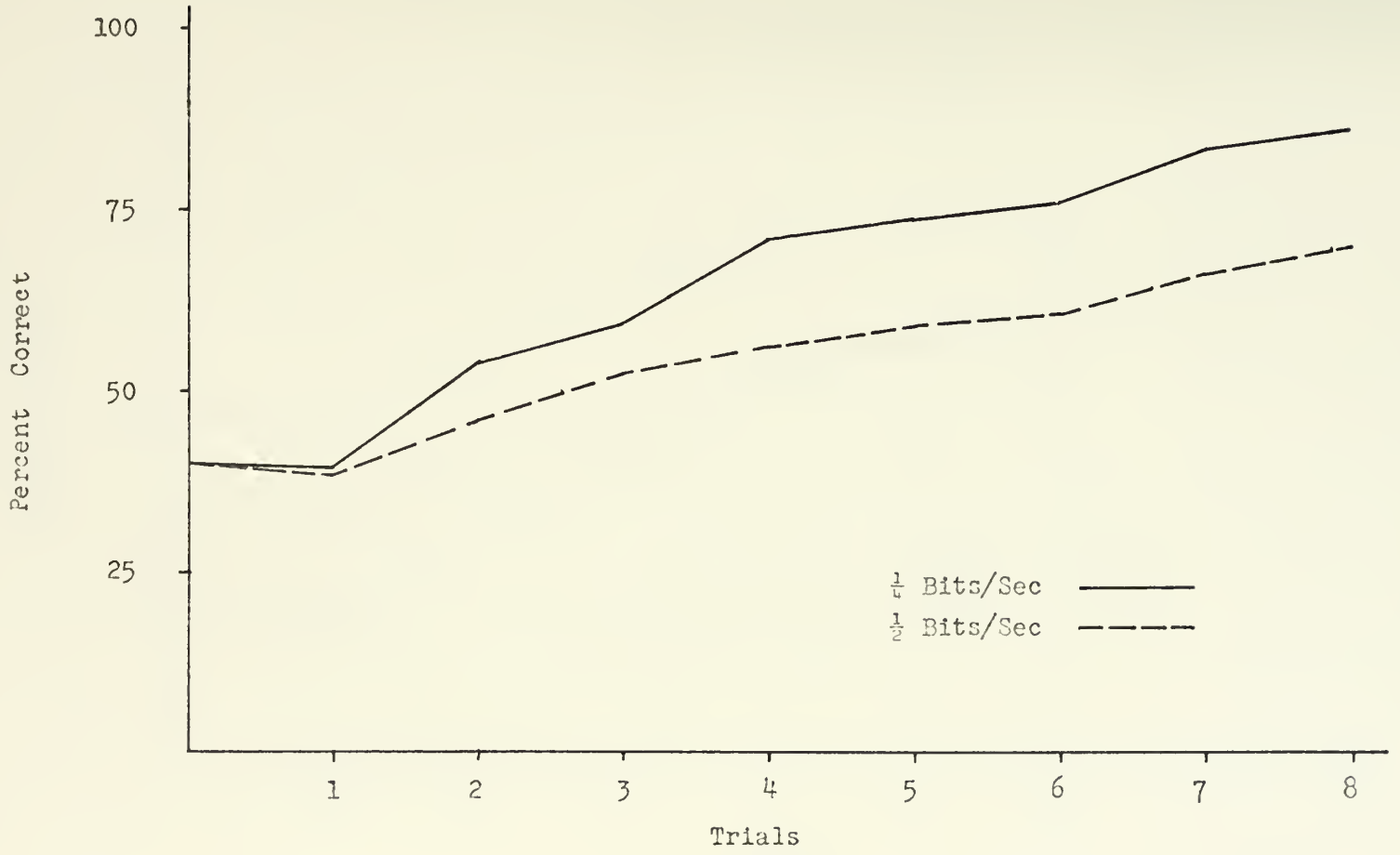

Figure 3. Comparison of Percent Correct Responses at the Two Presentation Rates

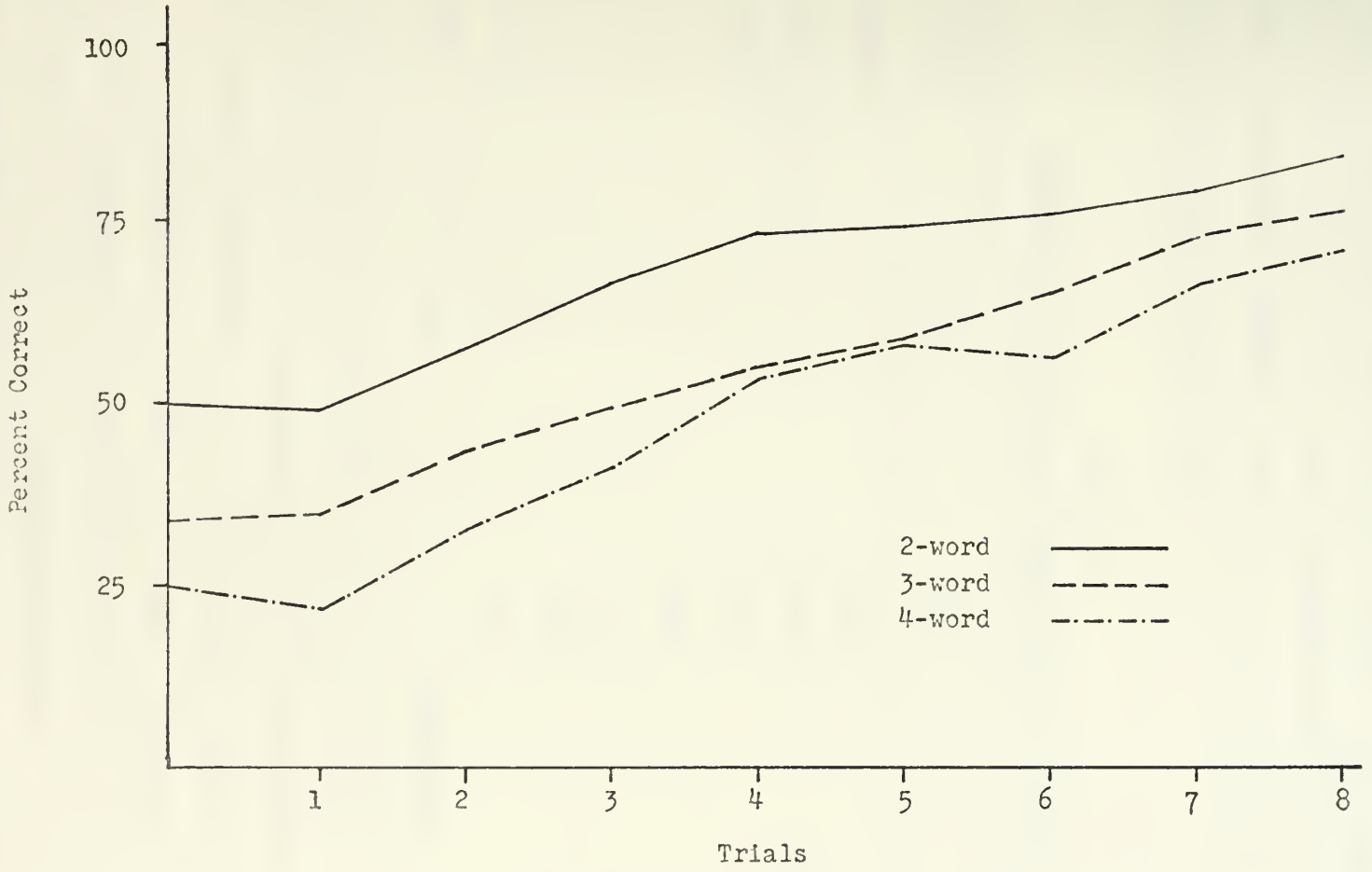

Figure 4. Percent Correct Responses per Item Length

As demonstrated by Gray (1971), the analysis of the percent correct data (Table VI) shows that the effects for rate, item length, trials, and rate x item length are significant with a probability less than 0.01. All except the significant interaction were expected. The primary purpose of this analysis, however, was to show the significance of item length as a variable, since the information analysis to follow predicts the null hypothesis (no difference) for item length.

TABLE VI

ANALYSIS OF VARIANCE OF PERCENT CORRECT RESPONSES

SOURCE	df	MS	F
RATE (A)	1	1254.61	71.22*
ITEM LENGTH (B)	2	1746.77	80.33*
TRIALS (C)	7	1159.55	53.32*
A x B	2	202.07	9.30*
A x C	7	44.98	2.07
B x C	14	26.45	1.22
A x BC	14	21.76	
TOTAL	47	*significant	

The first step in the information analysis was to compute the relative frequency that each choice was selected on its first presentation. For each item, each word within an item was arbitrarily designated as word 1, 2, 3, or 4 (depending on the number of choices). Chi-square tests indicated that the null hypothesis of equally likely alternatives could not be rejected ($\chi^2 < .95$) Thus, the a priori distribution is upheld by the empirical results (a posteriori distribution). The a posteriori probability for each classification is presented in Table VII.

TABLE VII

A POSTERIORI DISTRIBUTION OVER WORD LISTS

LIST	WORD 1	WORD 2	WORD 3	WORD 4	CHI-SQUARE
4 wd	21.00	25.00	28.50	25.50	0.90*
3 wd	34.15	37.10	28.75		1.18*
2 wd	50.25	49.75			1.15*

* $\chi^2 < 0.95$

Computing the information transferred required the determination of the distribution of choices for each item on each trial. This is accomplished by determining the number of times each word within an item was chosen during each trial within each of the six tasks. This forms a permutation of choices of either two, three or four words. Using tables of $p_i \log_2 p_i$, the uncertainty for the k-th item is

$$U_k = - \sum_i p_i \log_2 p_i$$

where i is the arbitrary designation of each word within the item. Table VIII gives all possible permutations of four numbers whose sum is equal to 10 (the number of subjects involved in each treatment) and their values of U_k. It is obvious that when perfect learning occurs, p_i for the correct choice is 1.00 and that there is no longer any uncertainty present in the item. Thus, for each test, the uncertainty remaining after each trial is

$$U = \sum_k U_k.$$

TABLE VIII

UNCERTAINTY U_k FOR 2-, 3-, AND 4-WORD ITEMS

WITH SUBJECTS (N) = 10

PERMUTATION OF CHOICES	$-\sum_i p_i \log_2 p_i$	PERMUTATION OF CHOICES	$-\sum_i p_i \log_2 p_i$
0 1 0 0	0.4690	5 3 2 0	1.4855
8 2 0 0	0.7219	4 4 2 0	1.5220
7 3 0 0	0.8813	6 2 1 1	1.5710
8 1 1 0	0.9219	4 3 3 0	1.5710
6 4 0 0	0.9710	5 3 1 1	1.6855
5 5 0 0	1.0000	4 4 1 1	1.7220
7 2 1 0	1.1568	5 2 2 1	1.7610
6 3 1 0	1.2955	4 3 2 1	1.8465
7 1 1 1	1.3568	3 3 3 1	1.8955
5 4 1 0	1.3610	4 2 2 2	1.9220
6 2 2 0	1.3710	3 3 2 2	1.9710

The U values for each treatment are shown in Table IX. Figures 5 and 6 graphically present this data.

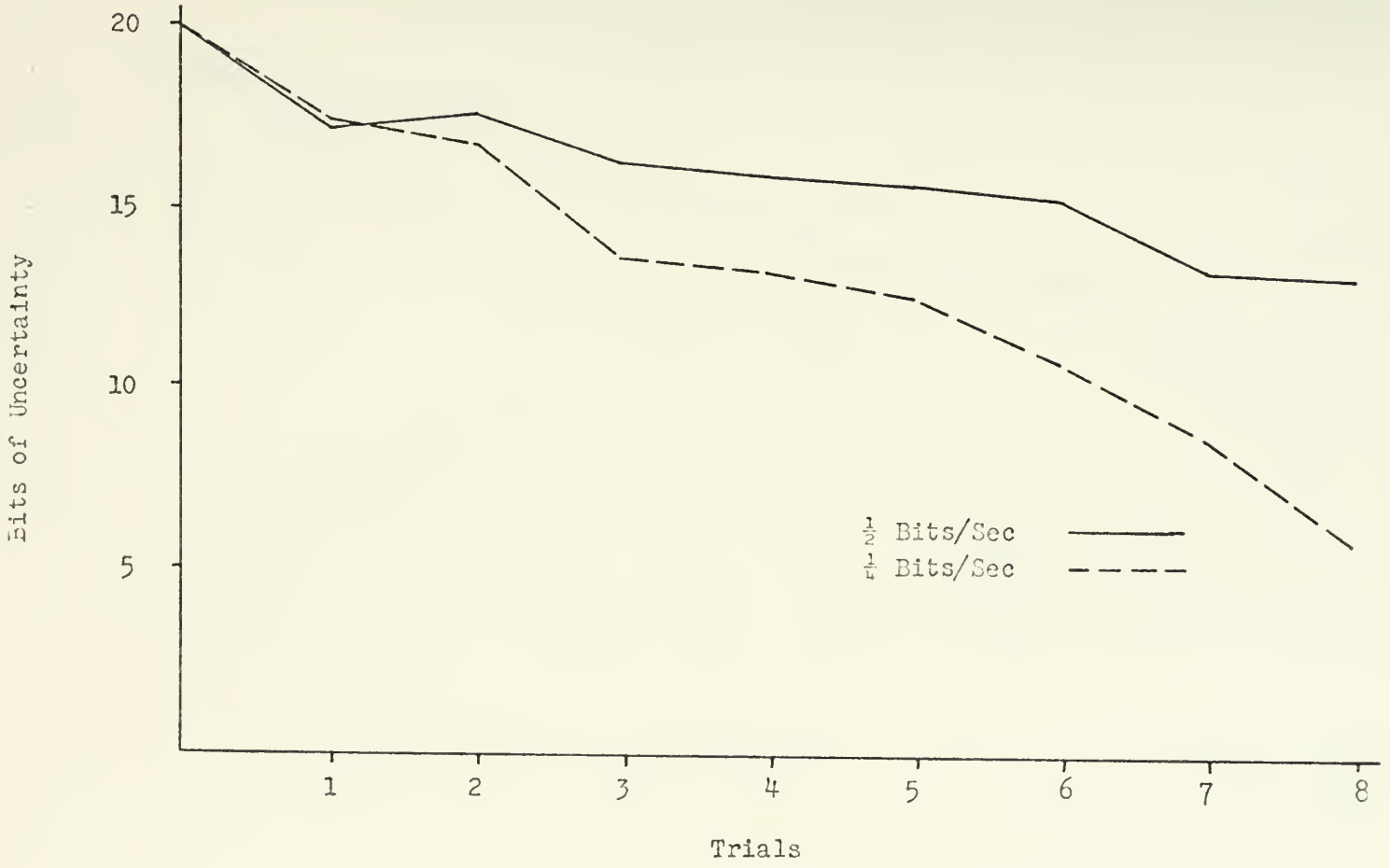

Figure 5. Uncertainty Remaining of the Two Presentation Rates

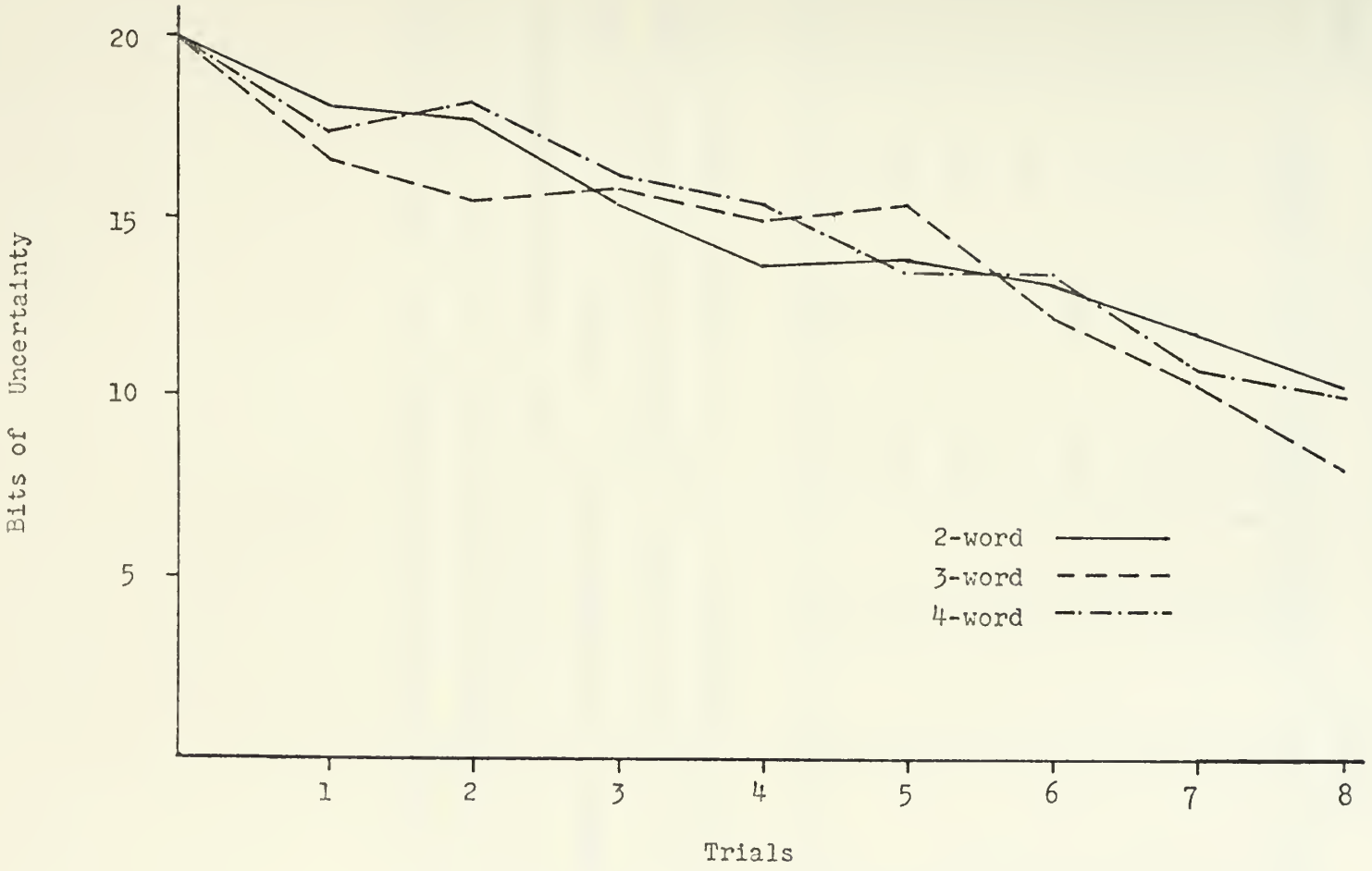

Figure 6. Uncertainty Remaining per Item Length

TABLE IX

UNCERTAINTY REMAINING PER PRESENTATION RATE OVER TRIALS

TRIAL	½ BITS/SEC			¼ BITS/SEC		
	2-WORDS	3-WORDS	4-WORDS	2-WORDS	3-WORDS	4-WORDS
1	17.8	16.5	17.4	18.3	16.6	17.1
2	19.3	15.6	17.6	16.1	15.1	18.6
3	16.6	15.5	16.6	14.2	16.1	15.6
4	16.7	15.4	15.7	10.7	14.3	14.9
5	16.7	14.5	15.7	10.9	16.0	11.2
6	17.3	13.6	14.6	9.1	11.0	12.3
7	15.9	11.7	12.4	7.9	8.9	9.3
8	15.1	10.6	13.5	5.7	5.6	6.4

This experiment conforms to a 2 x 3 x 8 randomized factorial fixed effects model; thus an analysis of variance over trials was conducted using nonrepeated measures. The basic datum for the analysis was the uncertainty remaining for each of 6 (item length $\left[3\right]$ x presentation rate $\left[2\right]$) treatments for each of eight trials making a total of 47 degrees of freedom. The results of the analysis are shown in Table X.

TABLE X

ANALYSIS OF VARIANCE OF UNCERTAINTY REMAINING

SOURCE	df	MS	F
RATE (A)	1	103.25	76.48*
ITEM LENGTH (B)	2	2.81	2.08
TRIALS (C)	7	46.22	34.17*
A x B	2	18.06	13.53*
A x C	7	8.64	6.38
B x C	14	1.60	1.18
A x B x C	14	1.34	
TOTAL	47		

*$p < 0.01$

The results of Table X indicate a statistical significance for the rate and trial main effects (Figure 5), while the item length main effect was not statistically significant; this insignificance can be seen graphically in Figure 6 and is explained by the fact that the information to be transferred is a constant in each treatment. The rate (Figure 7) main effect significance is apparent since twice as much information had to be processed at the faster rate of $\frac{1}{2}$ bits/sec. The significance of the trials' main effect occurs due to the learning process (i.e., the uncertainty reduction) which takes place over each trial and at an increased rate as learning progressed.

The rate by item length interaction significance is apparent in Figures 7 and 8 by a juxtaposition of the 2-word treatments relative to the other treatments for the two rates. The rate by trials interaction signi-

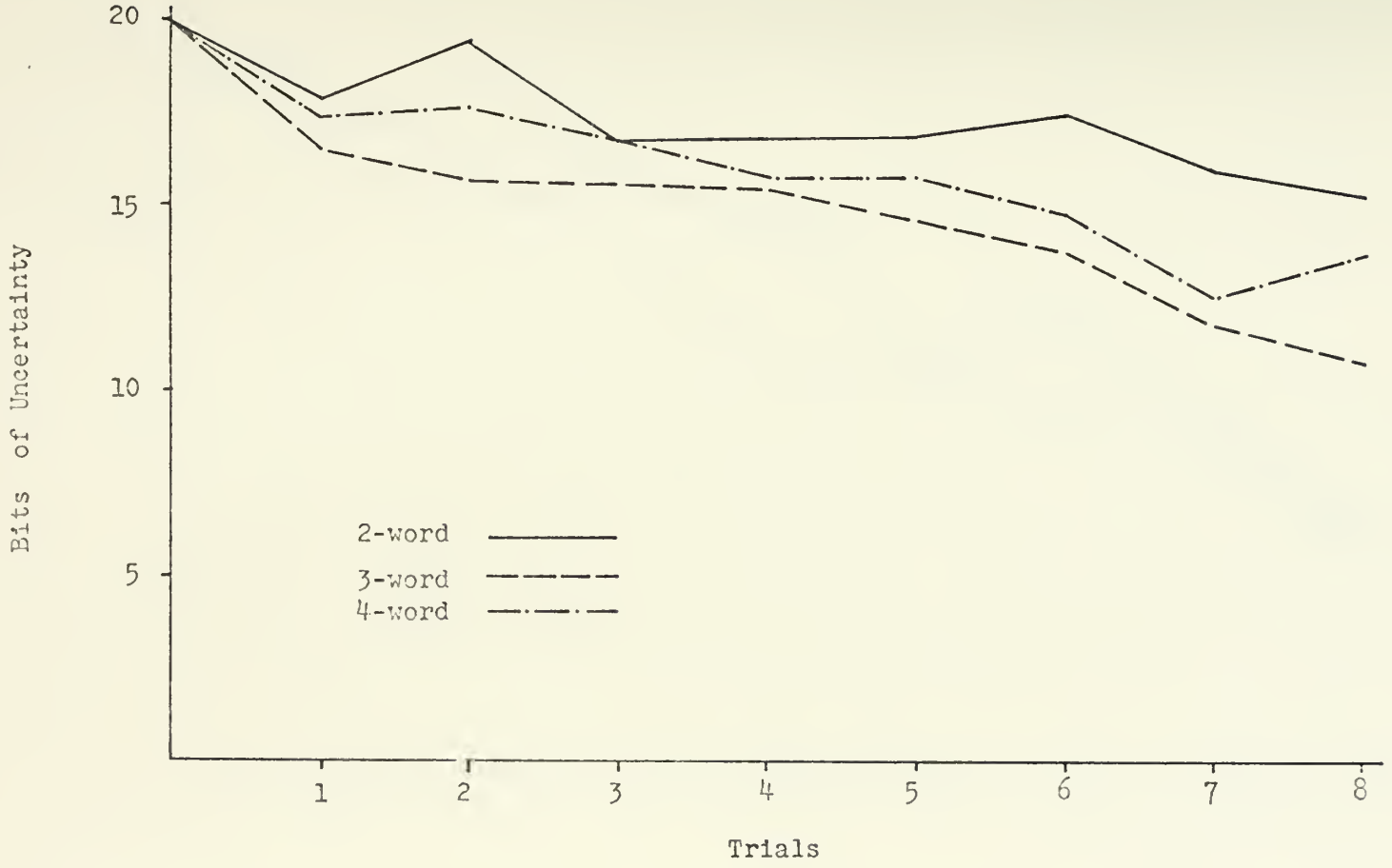

Figure 7. Uncertainty Remaining at a Presentation Rate of $\frac{1}{2}$ Bits/Sec

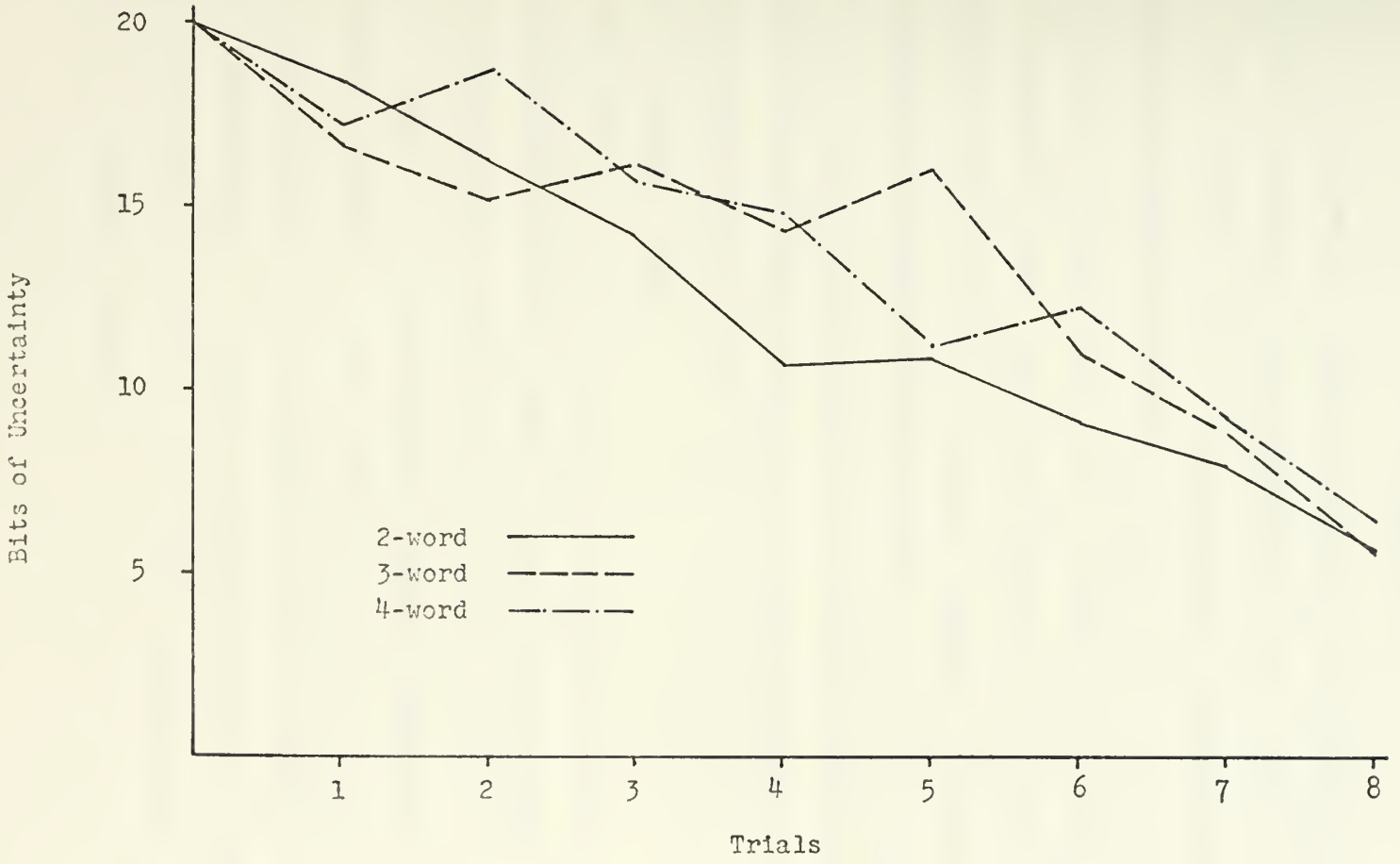

Figure 8. Uncertainty Remaining at a Presentation Rate of $\frac{1}{4}$ Bits/Sec

ficance is readily apparent in Figure 7, and is consistent with expectations.

IV. DISCUSSION

This experiment has demonstrated that the information measure provides an absolute measure of learning regardless of the number of alternatives (i.e., item length), whereas the percentage of correct responses showed that the item length main effect is significant. Thus it was possible to quantify the difficulty of a VD item in terms of the uncertainty remaining after successive trials. This was accomplished by creating lists of equal information content (workload) varying in length, differing in difficulty, and presented at distinct rates, resulting in making the work/rate condition twice as high for the groups with the shorter processing times. The results were consistent with the equal workload quantifications and showed that the differential in work output (information transferred) was approximately a factor of two.

The study has shown that information analysis provides a viable vehicle for measuring learning in VD tasks. Since a certain amount of basic education consists in rote learning, it is suggested that this type of analysis could be useful in future research to quantify learning tasks and progress. It should be possible to devise testing procedures to measure the rate of learning an individual can accomplish in order to determine such educational functions such as curricula, student placement in stratified classes, teacher-student workloads, and the like. Similar applications may be possible in training situations.

APPENDIX A

SUBJECT'S INSTRUCTIONS

You are to participate in a verbal discrimination experiment. You will be shown one series of either all 2-word items, all 3-word items, or all 4-word items, each item being distinct within the series. This series is 10, 12, or 20 items long and will be repeated in various orders for eight consecutive trials. Within each item, one word has been arbitrarily selected as "correct". Each item will be presented for a fixed length of time, followed by a blank space of the same duration.

It is your task to view the words in each item and guess which one is "correct". Once you have made a choice, announce it to the experimenter. If your response is "correct", the experimenter will tell you that you are "correct"; otherwise, no answer will be given. In each item, the "correct" response word will remain the same throughout the experiment.

Do you have any questions? If not, relax and await the experimenter's command to begin.

I wish to thank you for your assistance and would appreciate it if you would not discuss this experiment with other students who might participate in this study.

NUMBER OF CORRECT RESPONSES PER SUBJECT OVER TRIALS

2-WORD LIST AT ½ BITS/SEC

TRIAL	SUBJECT 1	2	3	4	5	6	7	8	9	10	TOTAL	% CORRECT
1	6	12	11	11	10	8	10	10	13	11	102	51.0
2	11	10	13	14	11	6	13	11	11	11	111	55.5
3	14	14	13	13	12	8	10	12	7	15	118	59.0
4	14	14	12	13	7	11	15	10	12	15	123	61.5
5	13	14	11	15	13	10	13	15	12	13	129	64.5
6	11	15	10	16	11	11	17	14	10	14	129	64.5
7	13	14	12	18	12	12	15	14	8	16	134	67.0
8	15	16	11	17	12	15	19	16	12	15	148	74.0

3-WORD LIST AT $\frac{1}{2}$ BITS/SEC

TRIAL	SUBJECT 1	2	3	4	5	6	7	8	9	10	TOTAL	% CORRECT
1	5	5	4	4	6	4	3	4	2	4	41	34.2
2	3	6	5	4	4	3	5	5	6	6	47	39.2
3	7	6	6	5	3	6	8	11	8	6	66	55.0
4	6	6	4	5	7	4	5	11	6	6	63	52.5
5	7	6	6	5	6	8	6	11	8	6	69	57.2
6	9	8	5	9	6	11	9	11	9	6	76	63.3
7	9	11	6	6	7	5	9	11	11	10	85	70.8
8	11	9	7	8	5	4	11	11	11	9	86	71.7

4-WORD LIST AT $\frac{1}{2}$ BITS/SEC

TRIAL	SUBJECT 1	2	3	4	5	6	7	8	9	10	TOTAL	% CORRECT
1	3	3	2	2	1	2	1	2	1	2	19	19.0
2	3	1	3	2	5	3	4	3	7	2	33	33.0
3	4	3	5	3	3	5	2	4	6	1	36	36.0
4	6	3	7	3	7	7	3	3	8	3	50	50.0
5	4	3	6	6	8	6	1	4	8	3	49	49.0
6	6	2	7	5	7	8	0	3	8	3	49	49.0
7	6	3	9	6	7	7	2	6	9	3	58	58.0
8	8	2	10	5	7	7	1	8	7	3	60	60.0

2-WORD LIST AT $\frac{1}{4}$ BITS/SEC

TRIAL	SUBJECT 1	2	3	4	5	6	7	8	9	10	TOTAL	% CORRECT
1	9	12	11	10	11	9	8	8	6	11	95	47.5
2	12	12	15	16	13	16	14	15	10	12	135	63.5
3	15	12	17	10	16	15	13	15	13	13	147	73.5
4	18	12	19	20	18	15	19	18	14	17	170	85.0
5	20	12	18	20	20	18	16	19	11	16	170	85.0
6	19	13	20	19	19	17	18	20	14	16	175	87.5
7	20	14	20	20	20	16	20	20	14	18	182	91.0
8	20	17	20	20	20	19	19	20	13	19	187	93.5

3-WORD LIST AT $\frac{1}{4}$ BITS/SEC

TRIAL	SUBJECT 1	2	3	4	5	6	7	8	9	10	TOTAL	% CORRECT
1	5	2	3	3	6	4	6	6	5	3	43	35.8
2	4	7	5	3	7	4	7	6	6	7	56	46.7
3	4	3	6	5	5	4	7	3	7	9	53	44.2
4	6	8	8	5	7	7	7	5	6	10	69	57.5
5	6	8	10	4	9	4	6	7	6	11	71	59.2
6	6	8	9	7	9	5	11	9	5	11	80	66.7
7	10	9	9	9	10	8	10	8	5	11	89	74.2
8	9	10	10	8	10	9	12	10	7	12	97	80.8

4-WORD LIST AT $\frac{1}{4}$ BITS/SEC

TRIAL	SUBJECT 1	2	3	4	5	6	7	8	9	10	TOTAL	% CORRECT
1	2	2	3	2	2	3	2	4	4	1	25	25.0
2	2	3	6	5	2	2	2	5	3	2	32	32.0
3	3	5	7	5	5	2	5	6	6	2	46	46.0
4	5	3	8	4	5	4	6	9	8	4	56	56.0
5	9	5	9	6	7	4	7	9	7	4	67	67.0
6	8	4	9	2	9	5	7	9	6	4	63	63.0
7	7	7	10	5	8	8	10	9	5	6	75	75.0
8	9	6	10	5	8	9	10	10	7	7	81	81.0

APPENDIX C

DISTRIBUTION OF CHOICES FOR EACH TEST OVER TRIALS

2-WORD LIST AT $\frac{1}{2}$ BITS/SEC

ITEM NO.	TRIAL 1		2		3		4		5		6		7		8	
	WORDS 1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
1	9	1	4	6	7	3	10	0	10	0	10	0	10	0	9	1
2	6	4	6	4	2	8	3	7	6	4	7	3	3	7	6	4
3	5	5	6	4	3	7	4	6	8	2	5	5	6	4	7	3
4	7	3	3	7	3	7	7	3	6	4	4	6	5	5	5	5
5	3	7	7	3	5	5	7	3	5	5	5	5	6	4	7	3
6	6	4	5	5	5	5	5	5	7	3	6	4	6	4	7	3
7	4	6	4	6	5	3	5	5	5	5	6	4	6	4	8	2
8	4	6	8	2	4	6	6	4	8	2	5	5	6	4	6	4
9	4	6	6	4	4	6	5	5	7	3	6	4	6	4	7	3
10	8	2	8	2	7	3	8	2	9	1	8	2	8	2	8	2
11	7	3	5	5	7	3	2	8	5	5	5	5	7	3	8	2
12	6	4	5	5	7	3	6	4	7	3	7	3	8	2	7	3
13	2	8	6	4	10	0	8	2	3	7	4	6	4	6	7	3
14	4	6	4	6	6	4	4	6	4	6	7	3	5	5	7	3
15	8	2	8	2	8	2	5	5	6	4	7	3	7	3	6	4
16	5	5	7	3	9	1	8	2	7	3	7	3	9	1	9	1
17	6	4	7	3	7	3	9	1	8	2	7	3	9	1	10	0
18	3	7	4	6	7	3	7	3	7	3	8	2	9	1	9	1
19	3	7	3	7	8	2	5	5	5	5	5	5	7	3	9	1
20	4	6	6	4	4	6	6	4	7	3	8	2	8	2	6	4

3-WORD LIST AT $\frac{1}{2}$ BITS/SEC

ITEM NO.	TRIAL 1			2			3			4			5			6			7			8		
	WORDS 1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	3	1	6	4	1	5	5	3	2	5	2	3	3	4	3	5	3	2	5	2	3	6	3	1
2	1	8	1	1	5	4	6	1	3	6	3	1	8	2	0	6	3	1	10	0	0	8	2	0
3	1	7	2	5	2	3	4	1	5	4	1	5	4	3	3	4	2	4	5	1	0	5	3	2
4	3	5	2	5	1	4	3	6	1	8	1	1	7	1	2	6	2	2	6	0	4	9	1	0
5	3	4	4	3	0	7	5	3	2	4	2	4	7	1	2	6	4	0	8	1	1	7	1	2
6	5	1	4	3	1	6	4	1	5	2	6	2	6	2	2	6	0	4	8	0	2	8	1	1
7	4	1	5	5	0	5	6	2	2	6	1	3	5	2	3	5	3	0	6	1	3	7	0	3
8	5	1	4	5	2	3	8	1	1	9	1	0	9	0	1	9	0	1	8	1	1	10	0	0
9	3	5	2	2	5	3	5	2	3	4	5	1	4	1	5	5	2	3	5	2	3	7	2	1
10	5	3	2	7	3	0	7	1	2	6	2	2	6	3	1	9	1	0	9	1	0	9	1	0
11	3	4	3	2	3	5	7	0	3	3	3	4	5	1	4	7	3	0	6	1	3	5	1	4
12	5	3	2	5	2	3	6	2	2	5	1	5	6	4	0	7	1	2	8	0	2	8	2	0

4-WORD LIST AT $\frac{1}{2}$ BITS/SEC

ITEM NO.	TRIAL 1 WORDS				TRIAL 2 WORDS				TRIAL 3 WORDS				TRIAL 4 WORDS			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	1	5	4	0	3	0	4	3	3	3	2	2	4	2	1	3
2	0	2	5	3	2	3	2	3	1	4	4	1	4	1	4	1
3	4	3	3	0	4	1	1	4	2	4	2	2	2	2	3	3
4	1	3	1	5	6	0	1	3	7	1	1	1	4	2	1	3
5	4	2	3	1	4	3	2	1	7	2	0	1	8	1	0	1
6	1	4	2	3	4	2	2	2	5	2	0	3	8	1	1	0
7	1	3	4	2	2	4	1	3	0	3	2	5	5	2	1	2
8	3	3	2	2	2	4	2	2	3	3	2	2	5	2	0	3
9	2	3	3	2	4	4	1	1	4	1	1	4	6	2	0	2
10	2	4	1	3	2	1	5	2	3	4	1	2	4	2	1	3

ITEM NO.	TRIAL 5 WORDS				TRIAL 6 WORDS				TRIAL 7 WORDS				TRIAL 8 WORDS			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	4	2	2	2	1	1	2	6	4	3	0	3	5	2	0	3
2	5	1	4	0	5	2	1	2	4	4	1	1	6	1	0	3
3	4	0	2	4	5	2	1	2	3	1	4	2	3	2	1	4
4	5	2	2	1	6	0	3	1	7	0	2	1	6	0	3	1
5	8	1	0	1	7	0	1	2	9	0	0	1	7	2	0	1
6	7	2	0	1	7	0	2	1	6	1	1	2	6	3	0	1
7	3	3	1	3	3	3	1	3	1	1	1	7	4	1	4	1
8	3	2	3	2	4	4	0	2	6	3	0	1	7	1	2	0
9	5	1	1	3	6	4	0	0	9	0	0	1	8	1	0	0
10	4	4	2	0	6	1	1	2	8	1	0	1	7	1	1	1

2-WORD LIST AT $\frac{1}{4}$ BITS/SEC

ITEM NO.	TRIAL 1		2		3		4		5		6		7		8	
	WORDS 1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
1	7	3	6	4	4	6	8	2	9	1	8	2	9	1	9	1
2	4	6	6	4	3	7	8	2	9	1	9	1	9	1	9	1
3	3	7	5	5	7	3	5	5	5	5	5	5	7	3	9	1
4	5	5	7	3	7	3	9	1	9	1	9	1	9	1	10	0
5	3	7	6	4	7	3	10	0	8	2	8	2	9	1	8	2
6	5	5	8	2	8	2	8	2	8	2	9	1	10	0	10	0
7	8	2	3	7	10	0	9	1	10	0	10	0	9	1	9	1
8	8	2	8	2	6	4	8	2	8	2	8	2	8	2	9	1
9	6	4	5	5	7	3	8	2	9	1	9	1	9	1	9	1
10	2	8	7	3	5	5	8	2	8	2	8	2	9	1	10	0
11	4	6	8	2	7	3	8	2	7	3	8	2	9	1	9	1
12	5	5	9	1	7	3	10	0	10	0	10	0	10	0	10	0
13	4	6	7	3	10	0	8	2	8	2	9	1	9	1	10	0
14	6	4	8	2	9	1	9	1	9	1	10	0	10	0	9	1
15	6	4	9	1	10	0	9	1	8	2	9	1	8	2	8	2
16	4	6	7	3	9	1	9	1	8	2	9	1	9	1	10	0
17	5	5	9	1	6	4	8	2	9	1	9	1	10	0	10	0
18	2	8	7	3	8	2	9	1	8	2	10	0	9	1	10	0
19	4	6	7	3	7	3	10	0	10	0	10	0	10	0	10	0
20	6	4	8	2	7	3	9	1	9	1	8	2	9	1	9	1

3-WORD LIST AT $\frac{1}{4}$ BITS/SEC

ITEM NO.	TRIAL 1			TRIAL 2			TRIAL 3			TRIAL 4			TRIAL 5			TRIAL 6			TRIAL 7			TRIAL 8		
	WORDS																							
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	5	0	5	6	3	1	3	1	6	8	2	0	6	1	3	7	2	1	7	1	2	7	1	2
2	3	1	6	4	0	6	4	5	1	7	2	1	6	1	3	9	1	0	10	0	0	10	0	0
3	5	3	2	4	4	2	4	3	3	5	1	4	3	2	5	7	0	3	6	1	3	5	2	3
4	4	3	3	5	3	2	5	1	4	2	3	5	4	3	3	8	0	2	7	2	1	8	1	0
5	5	1	4	4	4	2	5	1	4	9	1	0	7	2	1	8	1	1	10	0	0	10	0	0
6	3	2	5	3	5	2	5	3	2	5	1	4	4	4	2	8	2	0	9	1	0	9	1	0
7	1	4	5	2	3	5	4	2	4	6	1	3	7	2	1	9	1	0	7	2	1	10	0	0
8	1	3	6	4	4	2	4	2	4	4	4	2	4	2	4	6	3	1	6	2	2	10	0	0
9	2	2	6	3	0	7	0	3	7	4	4	2	2	3	5	3	4	3	3	3	4	4	6	0
10	4	1	5	7	3	0	8	2	0	9	1	0	9	0	1	9	0	1	10	0	0	9	1	0
11	4	4	2	8	2	0	4	2	4	5	2	3	5	2	3	8	1	1	6	2	2	7	1	2
12	4	2	4	5	1	4	5	2	3	5	2	3	4	2	4	6	2	2	8	1	1	8	1	1

4-WORD LIST AT $\frac{1}{4}$ BITS/SEC

ITEM NO.	TRIAL 1 WORDS				TRIAL 2 WORDS				TRIAL 3 WORDS				TRIAL 4 WORDS			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	4	0	2	4	3	1	5	1	5	1	2	2	5	2	1	2
2	2	3	2	3	5	1	1	3	6	3	1	0	5	0	2	3
3	1	3	2	4	3	2	2	3	4	1	4	1	5	4	0	1
4	1	2	3	4	1	4	3	2	4	1	3	2	7	0	1	2
5	2	0	4	4	4	2	1	3	5	3	0	2	7	1	2	0
6	3	3	4	0	3	2	2	3	6	2	1	1	4	2	1	3
7	4	1	2	3	5	1	2	2	3	3	0	4	6	0	2	2
8	5	2	1	2	4	2	2	2	4	4	2	0	5	2	2	1
9	1	1	4	4	2	2	4	2	6	2	2	0	7	1	1	1
10	0	3	5	2	2	2	3	3	3	0	2	5	5	3	1	1

ITEM NO.	TRIAL 5 WORDS				TRIAL 6 WORDS				TRIAL 7 WORDS				TRIAL 8 WORDS			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	4	1	0	5	4	3	2	1	5	1	1	3	6	0	1	3
2	8	0	2	0	8	1	0	1	8	0	1	1	9	0	0	1
3	5	3	0	2	5	2	2	1	6	1	2	1	6	4	0	0
4	7	1	0	2	8	2	0	0	8	0	2	0	9	0	1	0
5	8	0	1	1	7	1	1	1	9	0	1	0	9	0	1	0
6	5	1	1	3	7	2	1	0	9	0	0	1	10	0	0	0
7	7	2	0	1	5	0	3	2	7	0	0	3	8	0	0	2
8	5	1	2	2	6	1	1	2	7	2	1	0	7	0	3	0
9	10	0	0	0	10	0	0	0	10	0	0	0	10	0	0	0
10	8	1	1	0	5	2	0	3	6	0	2	2	7	0	1	0

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BSTRACT

Sixty Naval Postgraduate School students served in a verbal discrimination
VD) experiment with 2-, 3-, and 4-word items at presentation rates of $\frac{1}{2}$ or $\frac{1}{4}$
its of information per second. Half the items had similar and half, dissimilar
ords. Based on information theory, lists of different lengths were prepared
or 2-, 3-, and 4-word items. The lists were equated for overall load at 20 bits
f information. Performance was consistent with the equal-load hypothesis and
differential of two was observed because of the rate factor. Analysis of
ercent correct responses revealed a significance for the item length main effect
hich was at variance with the null hypothesis of no difference borne out by the
nformation analysis.

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
rbal Learning						
rbal Discrimination						
em						
rd List						
certainty						
formation Measure